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**Title:** Psychosocial Interventions in the Treatment of Severe Childhood Obesity: The SHINE Programme

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**Abbreviations:** SHINE: Self Help, Independence, Nutritional and Exercise, PSI: Psychosocial Intervention, WMP: Weight Management Programme, BMI: Body Mass Index, WC: Waist Circumference, SDS: Standardised value (e.g. BMI SDS), UK: United Kingdom.

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## **Abstract**

**Purpose:** Psychosocial Interventions (PSI) are characterised by three phases: 1) an initial in-depth assessment, 2) an intensive multifaceted intervention to stem a condition and 3) final phase an intensive maintenance programme. PSIs are often used in the treatment of mental health, however their application to adolescent obesity treatment are yet to be evaluated. This paper sought to evaluate the service level outcomes of a PSI for young people (aged 10-17) with severe obesity.

**Methods:** A retrospective evaluation of participants attending the SHINE programme between 2011-2016 ( $n = 435$ ; Age:  $13.1 \pm 2.1$  years, Male: 51%, White: 87.4%, BMI:  $33.5 \pm 7.5$  kg/m<sup>2</sup>, BMI SDS:  $3.1 \pm 0.5$  units). Differences in anthropometric (BMI & waist circumference) and psychosocial (self-esteem, anxiety and depression) outcomes were assessed 3 months from baseline. Differences at 6-, 9- and 12- months included anthropometric outcomes only. Participant retention was estimated through the presence of anthropometric data at baseline, 3-, 6-, 9-, and 12- months.

**Results:** Mean BMI SDS decreased by 0.19, 0.29, 0.35, and 0.41 units between baseline and 3-, 6-, 9-, and 12- months respectively. Waist circumference reduced by 9.7 cm and BMI by 2.4 kg/m<sup>2</sup> after twelve months. Ninety-five percent of participants were retained after 3 months, with 30.8% remaining after 12 months. All psychosocial measures improved favourably and significantly.

**Conclusion:** Participants who remained engaged in the programme had substantial reductions in anthropometrics at all time points. Results are positive in contrast to other weight management services suggesting the utility of, and warranting further exploration of, PSIs in the treatment of severe adolescent obesity.

**Key Words:** Psychosocial Intervention, Weight Management, Service Evaluation, Retention

## **Implications and Contribution**

SHINE - a psychosocial intervention - presents a novel and potentially effective means of treating adolescents with obesity. Psychosocial interventions focus on holistic health as opposed to traditional weight management focusing on weight loss. SHINE demonstrated significant improvements in psychosocial measures and anthropometrics with positive participant retention.

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Adolescence is a pivotal period of time in the lives of young people as they gain independence and autonomy. An alarming proportion of adolescents also have obesity; the Health Survey for England indicates that 35.2% of adolescents, aged 11-15 years, are overweight (16.4%) or have obesity (18.7%) [1]. Research further implies that obesity will track into adulthood for 22-90% of youths with obesity if intervention is not sought [2]. Many factors contribute to the prevalence of adolescent obesity which include low levels of physical activity, extensive bouts of sedentary periods and poor dietary behaviours. Psychosocial factors, such as low self-esteem, depression, anxiety and poor social relationships, are also known to correlate with obesity [3].

The United Kingdom (UK) currently implements a four-tiered approach to treating and preventing obesity, the Obesity Care Pathway [4]. The first tier of the pathway focuses on the prevention of overweight and obesity, primarily through marketing campaigns, awareness raising and knowledge building (e.g. Change4Life). The remaining three tiers of the pathway are dedicated to obesity treatment. The pathway stipulates that more specialist treatment is provided for children with a greater degree of obesity, insofar that Tier 2 provides generic weight management advice, Tier 3 provides specialist intervention from a multidisciplinary team and Tier 4 offers intensive treatment, pharmacology and bariatric surgery [4]. This pathway is primarily used in the management of adult obesity, and application in the management of severe obesity in young people (particularly Tiers 3 & 4) is limited. Recent data suggests that approximately 56% of local authorities have a Tier 2 service, and only 9% have a Tier 3 service for children and young people [5].

Traditional community-based weight management programmes (WMP) for young people (often at the Tier 2 level) predominantly focus on healthy eating, increasing exercise and behaviour modification [6; 7]. Such programmes usually last between 3 to 6 months [7]. Programmes adopting this approach often exhibit modest improvements in Body Mass Index (BMI) in the short-term, yet studies monitoring the long-term, post intervention effects frequently demonstrate weight regain [7]. Furthermore, traditional programmes will seldom address the psychosocial complexities presented by many adolescents with obesity [8].

SHINE (Self Help, Independence, Nutrition and Exercise) - a Tier 3, not-for-profit, community-based WMP in Sheffield - was established in 2003 for adolescents (aged 10-17 years) with severe obesity (standardised BMI [BMI SDS]  $\geq 99.6^{\text{th}}$  centile). SHINE recognises that the aetiology of obesity is complicated, and rather than focusing solely on the improvement of dietary and physical activity habits, the programme targets psychosocial areas of health which young people frequently exhibit alongside obesity, for example low self-confidence, stress, depression, and poor social relationships [8; 9]. The programme is a psychosocial intervention (PSI); defined as treating or preventing a condition using educational, behavioural and/or cognitive approaches [10]. Psychosocial interventions are conventionally administered in the treatment of mental health conditions, cancers, and HIV/AIDS [11; 12]; conditions which each share commonalities with obesity: chronic nature, negative psychosocial consequences and episodic relapses [13; 14]. SHINE considers the wider implications associated with obesity and therefore delivers a long-term programme to prevent weight deterioration and promote salubrious habit (re)formation.

PSIs are characterised by three distinct phases. Phase 1 is an acute stage where participants are assessed and signposted to the most appropriate method of treatment. Phase 2 comprises the active stage of the intervention; participants undertake an intensive, educational programme with the aim of stemming the condition (e.g. weight gain). The final phase, known as the maintenance stage, aims to educate participants how to sustain the behavioural changes made in Phase 2 – a superlative feature of PSIs. SHINE supports and educates the young person and their family in long-term, sustainable management of body weight.

To the extent of our knowledge, SHINE is the first WMP to adopt the PSI approach when providing a Tier 3 service. This paper will examine the anthropometric, psychosocial and retention related outcomes of the SHINE PSI. A secondary aim of the paper was to report the variables predictive of

initiating the programme, and moreover the variables predictive of continuing attendance into Phase 3 of the programme.

## **Methods**

### **Study Design and Setting**

A retrospective service evaluation of the SHINE programme was undertaken. No control or comparator group data was available. Participants must present with severe obesity (BMI SDS  $\geq 2.67$  units [99.6<sup>th</sup> centile]) or obesity (BMI SDS  $\geq 2.00$  units [98<sup>th</sup> centile]) with associated co-morbidities (e.g. Hypertension, Depression, T1 Diabetes) to be eligible [15; 16]. Phase 1 to Phase 3 spans 15 months if completed, but families may use the service ad hoc until the child's 18<sup>th</sup> birthday. Families pay a weekly fee (£5/\$8) to attend. The SHINE programme consists of three phases - aligned to the PSI approach. A comprehensive overview of the SHINE programme using the TiDieR framework [17] is available in a supplement.

### **Data**

SHINE provided participant data from September 2011 to March 2016 ( $n = 513$ ). Participants with a BMI SDS <98<sup>th</sup> centile were excluded from the analyses ( $n = 34$ ), as were those who attended a pilot programme ( $n = 42$ ), or with erroneous data ( $n = 2$ ), resulting in a final sample of 435 participants.

Parental consent, which stated that data may be used for evaluative/research purposes, was obtained by SHINE. Ethical clearance for secondary data analysis was provided by Leeds Beckett University Research Ethics Committee (*ref*: 13048).

### **Participant Entry Characteristics**

Participant information included gender, age (years), ethnicity (white or non-white), presence of a diagnosed learning disability, and the referral pathway (self-referral, school referral or professional referral [Physicians, Multi Agency Support Teams, Child and Adolescent Mental Health Services, and Social Services]). The referral pathway was collapsed into self-referral and non-self-referral due to low  $n$ -values per subgroup.

### **Anthropometric Measurements**

BMI ( $\text{kg}/\text{m}^2$ ) and Waist Circumference (WC [cm]) were standardised (SDS) for age using the UK growth reference data [15; 18]. Clinical cut-offs were applied to BMI SDS to provide weight classifications (obese [2.00 to 2.66 units, 98<sup>th</sup> to 99.5<sup>th</sup> centile], severely obese [2.67 to 3.49 units, 99.6<sup>th</sup> to 99.97<sup>th</sup> centile]) [15; 16]. An additional classification - very severely obese - was categorised as a standardised value exceeding 3.50 units, equivalent to the 99.98<sup>th</sup> centile [19]. All measurements were completed by the same senior obesity specialist and in accordance with standardised protocols [15; 18]. Data were collected at baseline, 3-, 6-, 9-, and 12- months, conditional on participant attendance.

### **Psychological Measurements**

Self-esteem, anxiety and depression were assessed through the Rosenberg Self-Esteem Scale [20] (higher scores represent greater self-esteem, range 0-30) and the Hospital Anxiety and Depression Scale [21] (higher scores represent higher anxiety/depression, range 0-21) respectively. These measurements were recorded at baseline and 3 months. Both measures are validated for adolescent cohorts [20; 22]. Measurements were not collected beyond 3 months in an attempt to reduce participant monitoring burden. Sample (*n*) values are considerably fewer as psychosocial measures were collected from late 2012 onwards.

### **Participant Engagement**

The presence of anthropometric data at each time point (baseline, 3-, 6-, 9-, 12- months) were used to identify participants engaged in the programme (sessional attendance data not available). Participants were termed Non-Initiators if they signed on to the programme and did not attend a session, therefore providing no anthropometric data. Those with anthropometric data until 3 months only were classified as Phase 2 Completers, and those with data beyond 3 months classified as Phase 3 Attenders.

### **Statistical Analysis**

Participant characteristics and anthropometric data were expressed through descriptives (mean, SD) and frequencies (%). Repeated-measures ANOVAs were used to evaluate change in anthropometry (BMI, BMI SDS, WC, WC SDS) between baseline and subsequent time points (3-, 6-, 9- and 12- months). Bonferroni post-hoc tests determined between time point differences. Additional Intention to Treat Analysis (Last Observation Carried Forward [LOCF]) were applied to BMI and WC (including SDS) to reduce attrition bias by forecasting future results based on the last measurement recorded [23]. Independent *t*-tests examined differences between binary groups (gender, ethnicity, and referral) and change in anthropometry at each time point. Paired samples *t*-tests determined the change in psychosocial measures from baseline to 3 months.

Frequency and percentage statistics assessed participant retention at each time point. Univariable and multivariable logistic regression models were used to examine which variables predict (1) Programme Initiation (start the programme) or Non-Initiation (do not start programme), and (2) Phase 2 Completion Only or Phase 3 Attendance. Multivariable models were developed using a backwards removal criteria – significant variables remained at the last step of the regression.

## **Results**

### **Participant Characteristics**

The majority of participants were white (87.4%), with a mean age of 13.1±2.1 years. Fifty-one (50.6%) percent of the cohort were male. Of note, 24.8% had a diagnosed learning disability (ADHD, Asperger's Syndrome, or Down's Syndrome). Regarding BMI SDS classification (*n* = 347): 19.0% had obesity, 56.2% had severe obesity and 24.8% had very severe obesity – the remaining 88 participants were Non-Initiators. Table 1 lists participant characteristics.

[INSERT TABLE 1]

## Phase 2 Outcomes

At 3 months, mean BMI SDS had reduced by 6.2% (BMI SDS reduction: 0.19, 95% CI: 0.17, 0.21) compared to baseline. Using LOCF analysis, the 3 month reduction was attenuated slightly by 0.01 units (BMI SDS reduction: 0.18, 95% CI: 0.16, 0.20). Notably, 27.0% of participants improved their BMI classification (e.g. classified with severe obesity at baseline and with obesity at 3 months).

Self-referrals had a significantly greater reduction in BMI SDS than those who did not self-refer (0.06, 95% CI: 0.02, 0.10;  $p = 0.00$ ). Self-referrals reduced BMI SDS by  $0.23 \pm 0.20$  units, with non-self-referrals achieving a  $0.17 \pm 0.18$  unit reduction. No significant differences in anthropometric changes were observed for gender or ethnicity.

Psychosocial measures all significantly improved also during Phase 2. Anxiety ( $n = 168$ ) decreased by 49.9% (baseline:  $8.85 \pm 5.32$ , 3 months:  $4.43 \pm 4.95$ ,  $p = 0.00$ ). Depression ( $n = 168$ ) also reduced from  $5.60 \pm 5.01$  units at baseline to  $2.57 \pm 3.91$  units after 3 months ( $p = 0.00$ ). Lastly, self-esteem ( $n = 157$ ) increased significantly within the 3 months by 38.1% (baseline:  $16.28 \pm 7.16$ , 3 Months:  $22.48 \pm 6.71$ ,  $p = 0.00$ ).

## Phase 3 Outcomes

Statistically significant reductions from baseline were found at 6, 9 and 12 months for all anthropometric measures (Table 2). BMI SDS decreases by 0.29 units after 6 months ( $n = 187$ ), 0.35 units after 9 months ( $n = 143$ ) and 0.41 units after 12 months ( $n = 107$ ) (Figure 1); equating to percentage reductions of 9.2%, 11.0% and 12.9% respectively. WC SDS demonstrated greater reductions than BMI SDS across all measurement points.

[INSERT TABLE 2 and FIGURE 1]

## Engagement and Retention

Of the 435 participants who signed onto the programme, 20.2% ( $n = 88$ ) did not attend the initial session (Non-Initiators). Three hundred and forty-seven participants consequently attended the first session. Eighteen (5.2%) participants did not complete Phase 2 of the PSI programme, leaving 329 (94.8%) participants after 3 months.

One hundred and eighty-seven participants (53.9%) opted to attend Phase 3 of the programme. After 9 months, 143 remained engaged and 107 after 12 months. Figure 2 presents participant retention throughout the first 12 months of the programme, relative to those who provided a baseline measurement ( $n = 347$ ).

[INSERT FIGURE 2]

## Programme Initiators and Programme Continuers

Model 1 examined variables predictive of programme initiation ( $n = 347$ ) or non-initiation ( $n = 88$ ). Self-referrers had a six times greater likelihood of initiating the programme than those from professional and school-based referrals combined (OR: 6.06, 95% CI: 3.2, 11.47). Participants with a diagnosed learning difficulty – as opposed to without - had 2.3 times greater odds of initiating the programme (OR 2.31, 95% CI: 1.21, 4.42). Age was not a significant determinant of programme

initiation in the final model. Overall variance in the outcome remained largely unexplained ( $R^2 = 0.12$  [Cox & Snell], 0.18 [Nagelkerke]).

Model 2 analysed variables which may be associated with completing Phase 2 only ( $n = 145$ ) or attending the Phase 3 intervention ( $n = 185$ ). A unit reduction in BMI SDS (in Phase 2) led to 11.2 times greater likelihood of engaging in Phase 3 (OR: 11.17, 95% CI: 2.92, 42.86). Additionally, those with higher baseline BMI were more likely to continue the programme (OR: 1.74, 95% CI: 1.11, 2.74). Again, the majority of the variance in the outcome was unexplained by these two variables ( $R^2 = 0.05$  [Cox & Snell], 0.06 [Nagelkerke]). No other variables were significantly associated with this outcome.

[INSERT TABLE 3]

## **Discussion**

Evidence relating to the evaluation of adolescent WMPs is limited, particularly when assessing those implemented within the UK [24]. Of those with published results, the programmes are often Tier 2 community-based interventions lasting between 3 and 6 months (e.g. MEND, GOALS, Families for Health). SHINE, a Tier 3 community-based WMP specifically for adolescents with severe obesity, was evaluated here to demonstrate the applicability of a long-term *psychosocial* intervention for treating obesity.

### **Short-term Outcomes**

Participants attending SHINE had a mean reduction of 0.19 units in BMI SDS during the first 3 months (Phase 2) – which compares favourably to other UK-based programmes [7; 24]. Upton et al. (2014) reviewed the outcomes of community-based WMPs in the UK and reported BMI SDS reductions ranging 0.01 [25] to 0.18 units [26] after 3 months of intervention. Moreover, the most recent Cochrane review of international pediatric WMPs demonstrated a pooled reduction of 0.14 units in BMI SDS after 6 months of intervention [27]. The results of SHINE are also significantly noteworthy when using Intention-to-Treat analysis to account for participants who did not complete a 3 month assessment, albeit that the result is slightly lowered.

SHINE has demonstrated that it may be highly efficacious in assisting young people with weight management; 89% of the participants either reduced (88.3%) or maintained (0.6%) their BMI SDS in the first 3 months. Establishing programme effectiveness though has long been of debate in weight management. One proposed method is to assess the volume of participants achieving a clinically significant reduction in BMI SDS (i.e. associated with cardiometabolic improvement) [28; 29]. The criteria for clinical significance is not agreed upon, but reductions of both 0.25 units and 0.50 units have been advocated and proposed as a goal for weight management [28; 29]. The findings of the current study indicate that only 35% and 5.6% of the cohort can achieve these clinical significant values respectively. Thus, achieving such thresholds is not likely to occur for the majority of WMP attendees, even at SHINE where the mean reductions in BMI SDS are greater than comparable programmes. Others too have questioned the utility of clinical significance [30]. Given the positive improvements in self-esteem, anxiety and depression at SHINE, it may be of greater benefit for policy makers and programme commissioners (those purchasing the programmes) to appraise



psychosocial outcomes rather than depending on weight-related outcomes. Indeed, many young people attend WMPs to primarily improve their psychosocial health [31].

With regards to engagement in weight management, Skelton and Beech (2010) point out that 8-83% of participants globally will not complete a paediatric WMP [32]. The discrepancy between the two values is likely due to the methodological differences between the programmes included (e.g. controlled clinical trials). However under service-delivery conditions and in the UK, GOALS [33] – an 18 session WMP for adolescents with obesity – noted a 52% programme completion rate (74/143 families), whilst WATCH IT [25] – a 3 month rolling WMP – showed a 76.6% completion rate (72/94 participants). MEND [34], the UKs largest childhood weight management provider, documented a 59.4% completion rate (8 311/13 998 participants). In the second phase of the SHINE intervention, participant retention was exceptionally high; 94.8% of those starting the programme completed a 3 month assessment. When examining those likely to initiate a WMP, the current study demonstrated that self-referrals were six times more likely to initiate the programme than non-self-referrals. This could indicate that the starting sample were highly motivated and ready to engage with weight management [35]. Latent reasons for high retention will also exist.

### **Long-term Outcomes**

Participants opting to attend the third phase of the SHINE PSI continued to show reductions in BMI SDS. During the 12 months of intervention, SHINE participants showed a mean reduction in WC of 9.7 cm and BMI of 2.4 kg/m<sup>2</sup>. In other UK-based programmes with BMI SDS data at 12 months, GOALS [33] evidenced a 0.09 unit reduction (based on 40/143 families) and MEND [36] a 0.23 unit reduction (based on 42/54 families). The meta-analysis within the Cochrane review estimated a pooled reduction of 0.14 units over 12 months, consistent with the estimate at 6 months [27]. SHINE reported a 0.41 unit reduction within the same duration (107/347 families). When attempting to account for the 240 families who did not attend at 12 months, the LOCF analyses indicated that the change in BMI SDS was reduced, though not to the extent that values began to increase (Figure 1).

Over half of the cohort chose to attend the third phase of SHINE. In particular, those with a higher baseline BMI SDS, or with large reductions in BMI SDS, were more likely to attend the final phase. A complete unit change in BMI SDS was associated with 11 times greater odds of continuing the programme which indicates that weight loss is a strong determinant for engagement (Change in BMI SDS: Phase 2 Completers = -0.16 units±0.17, Phase 3 Attenders = -0.23±0.20,  $p = 0.00$ ). As other studies have found that weight loss is associated with attendance [37; 38], this indicates that additional intervention must be targeted at those who have less noticeable changes in BMI SDS; the chronic nature of obesity needs to be recognised by families, as does the arduous journey in managing one's weight [14]. Yet for those choosing to continue into Phase 3, almost 60% (107/187 families) completed a 12 month assessment and further decreases in average BMI SDS was observed. It is apparent that a long-term WMP is beneficial for those wishing to continue their attendance, but future exploratory work is required to clarify these associations.

### **Psychosocial Interventions for the Treatment of Severe Obesity**

The National Institute of Health and Care Excellence (NICE) recommends that WMPs focus predominantly on dietary improvement, promotion of physical activity and behaviour modification [6]. SHINE, whilst acknowledging the NICE guidelines, goes further to recognise the psychosocial

aspects of obesity. A large proportion of the SHINE PSI focuses on developing social relationships, providing techniques for stress management, overcoming bullying, and improving self-esteem (see supplement 1). As such, SHINE may be viewed to offer more a more holistic approach to weight management than traditional programmes such as MEND, Watch It and GOALS. The type of approach taken by SHINE aligns with the Health At Every Size (HAES) paradigm, whereby treatment not only focuses on the direct determinants of a disease/condition (e.g. dietary intake for obesity) [39-41]. The HAES approach would stipulate that rather than focusing treatment outcomes on weight loss, emphasis be placed on the improvement of overall health, of which weight loss may be situated within [40].

Although SHINE does not collect psychosocial measurements beyond 3 months, a key objective of the programme is to improve the psychosocial health of the young person alongside assisting them with weight management. For the senior staff members at SHINE, the initial one-to-one assessment (60-90 minutes) is a fundamental opportunity members to explore both the physical and psychosocial health of the young person. In Phase 2, half of the course content targets the psychosocial determinants of obesity and the remaining half educates the young person on healthful nutrition, physical activity and behaviour modification. The final phase of the programme specifically addresses social relationships, healthy lifestyles and leisure time activities – all of which have a holistic focus. It may be that the alternative approach – which divides attention between the direct aetiology of obesity and psychosocial determinants – applied to weight management is a viable reason for SHINE's positive weight-related and psychosocial outcomes [31; 41].

### **Limitations**

This study is limited mainly because of the data being collected under service-level conditions; the absence of a control group, limited data upon participant attendance, and that psychosocial data were not collected beyond 3 months do limit its findings. That said, many WMPs are evaluated in such a manner and furthermore, many are not designed for the purposes of research. As researchers, we are able to utilise the data available to us to broaden the knowledge in the field of adolescent obesity. Future research would therefore benefit from the addition of a control or comparison group to help make the conclusions of this study more robust. Data collected beyond the length of the programme would too be of great benefit; establishing if young people can maintain their weight status/trajectory would further demonstrate programme effectiveness. The collection of additional data (e.g. attendance data, quality of life, social-confidence etc...) would lastly improve the strength of programme findings.

### **Conclusion**

This study has provided a several key and noteworthy findings. Firstly, psychosocial interventions appear to assist young people in the management of severe obesity, and possibly to a greater extent than other community-based WMP with published results. Not only do the results apply to anthropometric measurements, but anxiety, depression and self-esteem also improved significantly. Secondly, the participant retention within the second phase of the programme is exceptionally high, which continued to be encouraging for young people choosing to enter Phase 3. Reduction in BMI SDS and high baseline BMI SDS were shown here to be strong predictors of continued engagement

into Phase 3 of SHINE, highlighting that longer-term programmes are required by many and that such programmes be viewed as beneficial. In conclusion, current WMPs could benefit from addressing the psychosocial aspects of obesity whilst treating it as a chronic, relapsing condition and offering long-term service provision [3; 14].

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## **Tables and Figures**

**Table 1: Baseline Participant Entry Characteristics**

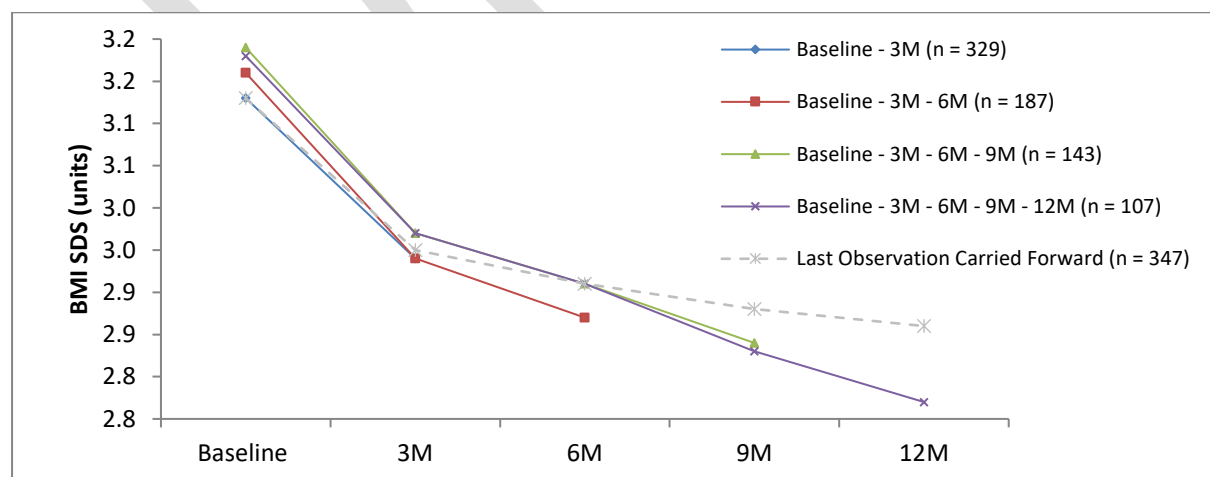
Characteristic	Total
<i>Gender (n, %)</i>	
Male	220 (50.6%)
Female	215 (49.4%)
Age [Years] (mean, SD)	13.09 (2.14)
<i>Ethnicity (n, %)</i>	
White	380 (87.4%)
Non-white	55 (12.6%)
<i>Learning Disability (n, %)</i>	
Yes	108 (24.8%)
No	327 (75.2%)
<i>Referral (n, %)</i>	
Self-Referral	190 (43.7%)
Non-Self-Referral	245 (56.3%)
BMI [kg/m <sup>2</sup> ] (mean, SD)	33.50 (7.45)
BMI SDS (mean, SD)	3.13 (0.54)
WC [cm] (mean, SD)	103.52 (14.67)
WC SDS (mean, SD)	3.62 (0.67)

**Table 2: Mean Difference in BMI, BMI SDS, WC and WC SDS**

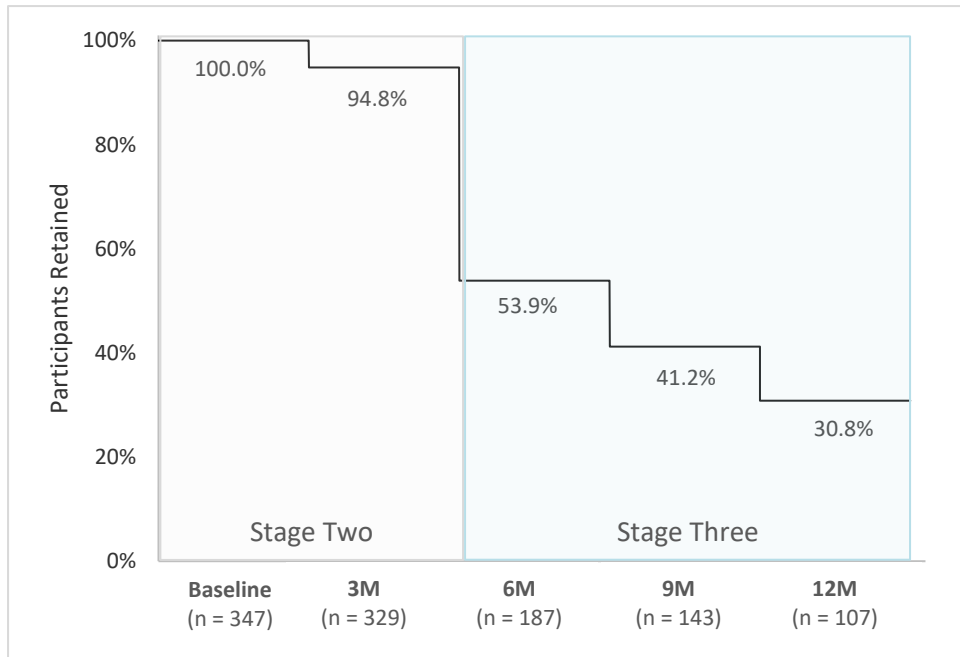
Time Period	Measure	n	Baseline	Mean Difference (95% Confidence Interval) <sup>b</sup>			
				3 Months	6 Months	9 Months	12 Months
Baseline	BMI SDS	347	3.13				
	BMI (kg/m <sup>2</sup> )	347	33.50				
	WC SDS	343	3.62				
	WC (cm)	346	103.52				
Baseline – 3M <sup>a</sup>	BMI SDS	329	3.13	-0.19 (-0.17, -0.21)			
	BMI (kg/m <sup>2</sup> )	329	33.42	-1.33 (-1.18, -1.49)			
	WC SDS	325	3.61	-0.38 (-0.34, -0.42)			
	WC (cm)	328	103.41	-7.42 (-6.77, -8.08)			
Baseline - 3M - 6M	BMI SDS	187	3.16	-0.22 (-0.18, -0.26)	-0.29 (-0.24, -0.34)		
	BMI (kg/m <sup>2</sup> )	187	33.58	-1.58 (-1.31, -1.84)	-1.87 (-1.51, -2.23)		
	WC SDS	184	3.68	-0.42 (-0.36, -0.48)	-0.49 (-0.42, -0.57)		
	WC (cm)	185	104.52	-8.34 (-7.32, -9.36)	-9.05 (-7.73, -10.36)		
Baseline - 3M - 6M - 9M	BMI SDS	143	3.19	-0.22 (-0.17, -0.27)	-0.28 (-0.22, -0.34)	-0.35 (-0.28, -0.43)	
	BMI (kg/m <sup>2</sup> )	143	33.73	-1.58 (-1.24, -1.92)	-1.85 (-1.39, -2.31)	-2.21 (-1.68, -2.73)	
	WC SDS	139	3.69	-0.41 (-0.32, -0.49)	-0.47 (-0.36, -0.57)	-0.51 (-0.40, -0.62)	
	WC (cm)	142	104.76	-8.17 (-6.90, -9.44)	-8.62 (-6.97, -10.26)	-9.08 (-7.28, -10.87)	
Baseline - 3M - 6M - 9M - 12M	BMI SDS	107	3.18	-0.21 (-0.15, -0.27)	-0.27 (-0.19, -0.35)	-0.35 (-0.25, -0.44)	-0.41 (-0.31, -0.51)
	BMI (kg/m <sup>2</sup> )	107	33.34	-1.41 (-1.00, -1.83)	-1.67 (-1.08, -2.26)	-2.08 (-1.39, -2.76)	-2.41 (-1.65, -3.17)
	WC SDS	103	3.69	-0.40 (-0.29, -0.51)	-0.46 (-0.32, -0.61)	-0.50 (-0.36, -0.65)	-0.57 (-0.42, -0.72)
	WC (cm)	106	104.31	-7.93 (-6.26, -9.59)	-8.23 (-6.05, -10.41)	-8.75 (-6.38, -11.11)	-9.74 (-7.31, -12.12)
Intention to Treat Analysis (LOCF)	BMI SDS	347	3.13	-0.18 (-0.16, -0.21)	-0.22 (-0.18, -0.26)	-0.25 (-0.21, -0.29)	-0.27 (-0.23, -0.32)
	BMI (kg/m <sup>2</sup> )	347	33.50	-1.26 (-1.05, -1.48)	-1.42 (-1.15, -1.70)	-1.57 (-1.27, -1.87)	-1.67 (-1.35, -1.99)
	WC SDS	343	3.62	-0.36 (-0.30, -0.41)	-0.40 (-0.33, -0.46)	-0.41 (-0.35, -0.48)	-0.43 (-0.37, -0.50)
	WC (cm)	346	103.52	-7.04 (-6.11, -7.96)	-7.42 (-6.34, -8.49)	-7.60 (-6.48, -8.72)	-7.93 (-6.79, -9.06)

<sup>a</sup>M: Month

<sup>b</sup>Significant difference between baseline and all time points ( $p \leq 0.05$ )



**Figure 1: Monthly (M) Change in Mean BMI SDS**



**Figure 2: Monthly (M) Participant Retention**

**Table 3: Predictors of Non-Initiation (Model 1) and of Attending Phase 3 (Model 2)**

Variable	Univariable Models		Multivariable Model	
	OR	95% CI	OR	95% CI
<b>Model 1: Non-Initiators (n = 88) vs. Initiators (n = 347)</b>				
Constant	-	-	8.34	-
Male	1.09	0.68, 1.74	-	-
Age	0.83**	0.74, 0.93	0.90	0.80, 1.01
White Ethnicity	1.41	0.73, 2.73	-	-
Self-Referral	6.01***	3.21, 11.23	6.06***	3.20, 11.47
Learning Disability	1.96*	1.06, 3.65	2.31*	1.21, 4.42
<b>Model 2: Complete Phase 2 only (n = 145) vs. Attended Phase 3 (n = 185)</b>				
Constant	-	-	0.14*	-
Male	0.79	0.51, 1.22	-	-
Age	1.01	0.91, 1.13	-	-
White Ethnicity	0.96	0.49, 1.90	-	-
Self-Referral	1.09	0.71, 1.69	-	-
Learning Disability	0.79	0.48, 1.29	-	-
Baseline Anxiety	1.04	0.98, 1.11	-	-
Change in Anxiety <sup>a</sup>	0.98	0.91, 1.06	-	-
Baseline Depression	1.01	0.95, 1.08	-	-
Change in Depression <sup>a</sup>	1.02	0.94, 1.11	-	-
Baseline Self-Esteem	1.03	0.98, 1.08	-	-
Change in Self-Esteem <sup>a</sup>	0.98	0.93, 1.04	-	-
Baseline BMI SDS	1.31	0.87, 1.97	1.74*	1.11, 2.74
Change in BMI SDS <sup>a</sup>	6.83**	1.96, 23.88	11.17***	2.92, 42.86
Baseline WC SDS	1.43*	1.02, 2.01	-	-
Change in WC SDS <sup>a</sup>	2.62**	1.30, 5.30	-	-

<sup>a</sup> Difference between baseline and 3 months

Model 1:  $R^2 = 0.12$  (Cox & Snell), 0.18 (Nagelkerke). Model  $X^2(3) = 53.47$ .

Model 2:  $R^2 = 0.05$  (Cox & Snell), 0.06 (Nagelkerke). Model  $X^2(2) = 15.83$ .

\* $p \leq .05$ , \*\* $p \leq .01$ , \*\*\* $p \leq .001$

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## Supplements

### Supplement 1: Comprehensive Programme Overview - TIDieR Framework

#### Programme Rationale

The programme was developed to fulfil a gap in provision of weight management services for children and young people, aged 10-17 years, with severe obesity. Severe obesity is not yet internationally classified, however within the UK a standardised BMI  $\geq 99.6^{\text{th}}$  centile of the UK90 growth reference charts are often used to identify this population group [1]. At present throughout the UK, limited intervention is offered to those who are severely obese, and as a result, require a Tier 3 programme [2]. Tier 3 programmes often consist of multi-disciplinary input and more intensive intervention. SHINE sought to work within this operational deficit for Tier 3 programmes in Sheffield.

The mission aim of the programme is:

*“To help young people to understand their weight problem so that they can manage it more effectively in an independent way” [3].*

#### Programme Procedures

**Referral:** Participants refer via: self-referrals, GP referrals, CAMHS referrals (Child and Adolescent Mental Health Services), school referrals, Sheffield Children’s NHS Foundation Trust referrals and referral from social services (including those on care plans). Other smaller referral avenues also exist.

Participants are eligible for the intervention with a BMI SDS  $\geq 2.67$  units; classifying the individual as above the 99.6<sup>th</sup> centile [1]. Participants are also accepted who have a BMI SDS  $>98^{\text{th}}$  centile (BMI SDS  $\geq 2.00$  units) and with associated co-morbidities (e.g. Depression, Hypertension, Fatty Liver Disease, and T1D Diabetes).

**Pre-programme:** Phase 1 of the PSI approach invites families to attend an in depth, pre programme assessment with a senior member of the SHINE team (includes assessment of physical, psychological, behavioural and social needs of the young person). The session provides young people and their family with an overview of the programme content and an opportunity to discuss any weight-related issues. The family is also informed on the severity of obesity, and programme staff seek to ensure the family understand their responsibility in the management of their child’s obesity [4]. Families are signposted to the most suited programme using a stepped care approach [5].

**Programme:** Most families (~95%) who attend the one-to-one assessment are signposted to the 12 week intervention delivered by SHINE. This is the Phase 2 of the PSI approach. Children are educated independently from their parents. Although the programme does not educate both parents and children simultaneously, the parents are offered a training day in which all session content is covered. In some instances, parent sessions have run concurrent to sessions for the children – this is not standardised across the programme but determined by need. For the 5% of participants who are not signposted to the PSI programme, they are offered alternative treatment options (e.g. one-to-one therapy). This is due to the complexities of this small subgroup, and the knowledge that a group-based PSI programme may not yet be an appropriate treatment. This subgroup are not included in these analyses.

The first and last week of the programme are dedicated to introduction and celebration respectively. Week’s 2 to 6 educate participants about dietary modifications which align to the guidance of NICE

(2013) and thus includes sessions on portion control, healthy alternatives, food labelling etc... During week's 7 to 11, the programme focuses on the psychosocial elements of obesity: targeting self-esteem, satiety and self-control, body image perceptions, stress management and support on bullying. All sessions are designed to be interactive and engaging, often consisting of group work and practical demonstrations/activities.

Physical activity sessions are run throughout the week by SHINE. These use local facilities and are exclusive for the participants. A total of seven hours, optional physical activity is available. This includes swimming sessions, game-based sessions and circuit/gym work. The sessions aim to be enjoyable and inclusive for participants. Participants pay a membership fee of £5 per week.

**Maintenance:** The maintenance programme of SHINE is Phase 3 of the PSI approach. Participants are invited to attend the maintenance programme upon completion of Phase 2. The maintenance programme is made up of three modules, each lasting approximately 12 weeks with weekly contact (1. Healthy Lifestyles, 2. Managing Social Relationships and 3. Making the Most out of Leisure). In total, participants can attend SHINE for up to 15 months, however some stay with the programme longer.

The maintenance modules have health and obesity management related content interwoven into all sessions i.e. personal hygiene, relationship development, benefits of healthy eating etc... Some modules behold nationally recognised accreditation which provides employability and life skills to the participant. Additional opportunities are available for participants such as Duke of Edinburgh, one to one counselling and psychotherapy – uptake of these sessions is low relative to the three main modules.

**Follow Up:** No formal follow up processes are in place.

### **Materials Used**

Staff are provided with session plans for the Phase 2, 12 week programme: this outlines the delivery of the sessions, appropriate delivery style and helps to ensure programmes are delivered in a standardised manner. Standardised session plans are also provided for the maintenance (Phase 3) modules within the SHINE programme. Several of the maintenance modules are designed around a nationally recognised accreditation body, which provides a framework for the session plans and materials used. Portfolios can be submitted by participants to gain a nationally recognised qualification in Personal and Social Development.

A number of incentives are provided for participants on the SHINE programme. These include portion control plates, lunch boxes, pedometers, certificates and prizes for the final week celebration.

### **Programme Provider**

SHINE is a not-for-profit organisation. Sources of funding are therefore from trusts, charities and private avenues. This funding enables approximately 100-150 new participants to attend each year.

The core team of SHINE employees/volunteers ( $n = 30$ : 67% Graduates) is relatively small, and has the input of a Board of Directors, each Director with expertise in their respective areas. Phase 1 of the PSI approach is delivered by a senior, experienced member of staff. Phase's 2 and 3 are delivered by the core team: predominantly final year/post graduate university students who have all completed a minimum of one year, in-house training.

Specialist staff members (qualified therapists, nutritionists, psychologists, nurses and youth workers) are available should an individual require one to one, intensive intervention.

### **Mode of Delivery**

The first phase (one-to-one assessment) of the PSI programme is delivered to the individual family unit.

The second phase (12 week programme) is group-based. Initial groups comprised of ≈20 participants, however recent programmes often have 10-15 participants as the complexities of those attending have increased.

The third phase of the PSI approach (maintenance programme) is predominantly delivered in small groups (10-15 participants). For participants who require specialist intervention (e.g. nutritional or counselling therapy), sessions are delivered on a one-to-one basis.

### **Programme Location**

SHINE is located in one of Sheffield's most highly deprived areas. Many of the participants live within a short distance of the central venue, although some travel from further parts of Sheffield.

The central venue is used by Phases 1 to 3 of the PSI approach, though some of the maintenance modules are delivered in external settings. The venue has the appropriate resources for group-based activities and a common room/lounge area for parents. A separate room is used for anthropometric assessments to ensure privacy. A private therapy room is used for the one to one sessions/assessments.

Physical activity sessions use local sports/leisure facilities.

Sessions predominantly run on a weekday evening (between 6-8pm) or a Saturday morning, dependent on the module/intervention phase being attended.

### **Programme Frequency/Duration**

The Phase 1 assessment lasts for approximately 1-1.5 hours dependent on the participant.

Phase 2 is 12 weeks in length, with weekly sessions typically lasting 1-2 hours dependent on the learning ability of the group. Physical activity sessions last approximately 1-2 hours.

The maintenance programme (Phase 3) varies by module attended. The three main modules require participants to attend 12, weekly sessions of one hour. Should a participant attend for therapy, they are offered six to eight sessions– each lasting 50 minutes. Hourly, one to one nutrition sessions are available to those with increased dietary needs (i.e. T1 Diabetes) or who have experienced relapse or weight regain.

Sessions are arranged around public holidays/mid-term school holidays and resume again once school re-commences. Programme running dates align with the school terms (Jan – March, April – July, September - December).

Drop in sessions are available to all young people throughout their attendance. These are booked on a 'needs' basis and are not utilised by all.

## **Tailoring**

SHINE is tailored to the individual from the outset. Through the provision of the stepped care approach, families are signposted to the best suited (agreed by family and SHINE) level of care delivered by SHINE. Although many families go on to attend the 12 week Phase 2 programme, some are offered individualised counselling when deeper, psychological issues arise. Parent sessions can be delivered concurrent to the 12 week programme for the young people. These are optional for the parents to attend.

Participants have an assessment from SHINE every 6 weeks with content similar to the initial assessment. Parents accompany their child – this gives families time to have a detailed discussion with a senior SHINE staff member on any weight-related issues.

On completion of a module, families are informed of other opportunities provided by SHINE that they may wish to attend. One to one counselling and family intervention work is also offered at this point if needed.

Families can also contact the senior staff members at any point in time throughout their attendance. This contact could be via phone, email or a personal meeting.

## **Programme Modifications**

Programme modifications have been informed by the evaluation and feedback received from families and young people. Modifications include: making the sessions more interactive, delivering more demonstrations and learning through games and experiential activities. SHINE has a Young Peoples Management Committee (YPMC) which meets at the end of each module and feedback the comments of their participating peers. The Chair of the YPMC can suggest programme modifications to the Board of Directors.

## **Programme Reporting and Fidelity**

SHINE has developed since its establishment in 2003. The delivery is standardised through detailed session plans for all module sessions. In addition, the majority of the programmes are run from the central venue in Sheffield which ensures sessions are delivered in a consistent manner upholding strong programme fidelity.

Session fidelity is dependent on the programme participants and the complex needs of these participants. Approximately one in four participants attending SHINE has a diagnosed learning disability and sessions are adjusted to cater for these needs in terms of session length, delivery method and staffing requirements. Staff members still aim to satisfy the sessional objectives independent of participant need.

Data is recorded by a senior staff member at the point of data collection. Data has been stored electronically since 2011 on a database and can be accessed by senior staff members.

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